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Measurement of Power Frequency with Higher Accuracy using PIC Microcontroller

Khairul Alam[1], Tanmoy Chakraborty[2]*, Srabana Pramanik (Chaudhury)[3], Debabrata Sarddar[4], Satadal Mal[5]

[1]Advance Integrated Tech. Lab, Kolkata, West Bengal, Pin-700014, India.

[2]Department of Computer Science and Engineering, Saroj Mohan Institute of Technology, Guptipara, Hooghly, West Bengal, Pin-712512, India.*

[3]Department of Computer Science and Engineering, Camellia Institute of Engineering, Madhyamgram, Kolkata, West Bengal, Pin-700129, India.

Abstract

Frequency measurement is an important issue in the field of electrical engineering. Electric power system has become complex over the last decade. The use of distributed generation, the connection of non-linear loads and the presence of some unexpected system faults are the main causes of frequency variations. In addition, power quality includes frequency as a most important index. This paper deals with digital measurement of power frequency i.e. 50Hz using microcontroller based system. This measurement system measures the frequency up to three decimal accuracy. This is generally very useful in load frequency control of power system.

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* Corresponding author. Tel.: +0-943-399-2854;
E-mail address: tanmoy.chakraborty@yahoo.com

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1. Introduction

The conventional measurement of frequency is vibration reed type. This has become obsolete with time. The present digital electronic measurement is far better than the previous mechanical vibration reed type method. When frequency is taken as feedback parameter, this has to be measured accurately for control purpose. The simplest method of measuring frequency is to convert the sinusoidal frequency into square wave and count the square wave signals for one second but this measurement lacks the accuracy of ± 2% because of one count inherent error in digital system and putting the constraint in monitoring and control system. Hence the present system presents a very accurate system of frequency measurement.

2. Related Work

The paper [1] also measures the frequency using Z-80 microprocessor based system. It proposes so many digital hardware peripherals and the processor to measure the frequency and the designer should have the expertise in digital circuits as well as microprocessors. In the paper [2], [4] also measure the frequency using microprocessor based system. It uses frequency divider, external timer and interrupt controller along with the processors with an accuracy of two decimal points. The paper [3] also measures frequency with accuracy comparable with the system developed but the method is much more complex and difficult to realize. In comparison with the papers mentioned above, our system is compact, economical, and easily realizable and can be embedded to any complex system for measurement and control.

3. Proposed Work

The frequency sample is collected from the secondary of a transformer, shown in equation no. *(1)*. It is allowed to pass through a Zero Crossing Detector (ZCD), converted into a square wave. The square wave is supplied to a counter. The counter is incremented by a 400ns interval crystal controlled pulse to measure the number of counts during two falling edge of the square wave. This will basically measure the full time period of that square wave signal. Fig.1 (a) shows the sinusoidal wave of unknown power frequency, being the output of a step-down transformer. The equation of the instantaneous sinusoidal wave is given below. Fig.1 (b) shows the output of a Zero Crossing Detector (ZCD). The time duration between the falling edges of the square wave represents the time period of unknown frequency. Fig, 1(c) shows the pulses of 400nano second (ns) interval, generated from a crystal controlled oscillator.

$$v=V_m \sin \omega t=V_m \sin 2\pi ft \tag{1}$$

Where, v – Instantaneous sinusoidal voltage in volts.

V_m – Peak voltage of the sine wave in volts.

ω – Angular frequency in radian per second.

f – Frequency in Hz.

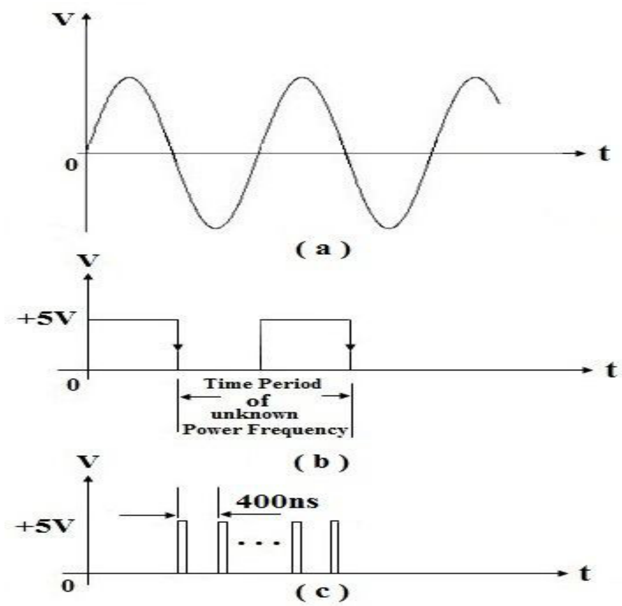


Fig. 1(a): The sinusoidal wave of unknown power frequency, being the output of a step-down transformer.
Fig. 1(b): The output of a Zero Crossing Detector (ZCD).
Fig. 1(c): The pulses of 400 nano second (ns) interval, generated from a crystal controlled oscillator.

The count value during this total time Period multiplied by 400ns offers the total time period of the signal. The inverse of the period is the required frequency with ±1 count accuracy i.e.±0.002% accuracy. The time period as well as frequency is displayed on 16X2 LCD display and PC interfaced with USART (Universal Synchronous Asynchronous Receiver Transmitter) for further data analysis.Fig.2 shows the system overview.

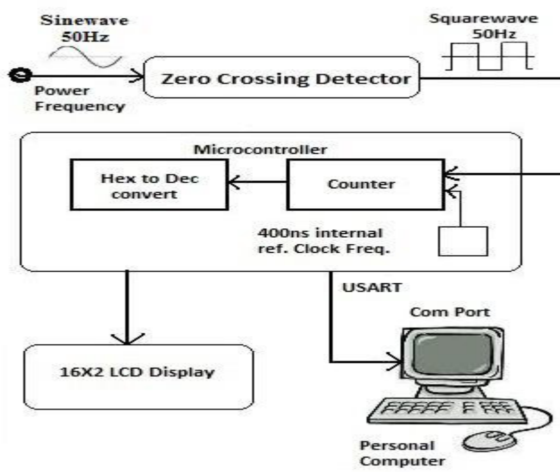
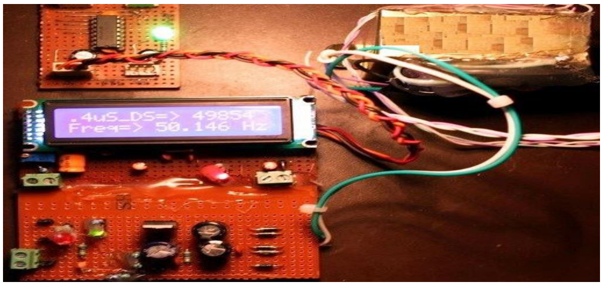


Fig.2: System Overview

A step-down transformer with the specification of 220 volt to 12 volt has been used for this purpose. A regulated power supply is designed to power up the entire microcontroller system and its peripherals. The another part of the output voltage is given through a Zero Crossing Detector, designed by a high speed voltage comparator to get accurate square wave of the sine wave. The square wave has taken as an input to an external interrupt pin of the



microcontroller PIC 16F877A. The external interrupt is configured in the falling edge. The data flow diagram is shown in Fig.3.

Fig. 4: Microcontroller based Power Frequency Meter

The Timer 1 is used to calculate the time between two falling edges. Its prescaler set to 1:1 which means one increment of the timer takes [1/ (external crystal frequency/4)], i.e. 0.4µs. This is the multiplying factor. The count value multiplied this factor is the appropriate time of the frequency in micro second order. Now the total time count is divided with 1X 10^6 to get the value in second. The frequency is the reciprocal of the time period. The Microcontroller based Power Frequency Meter is shown in Fig. 4.

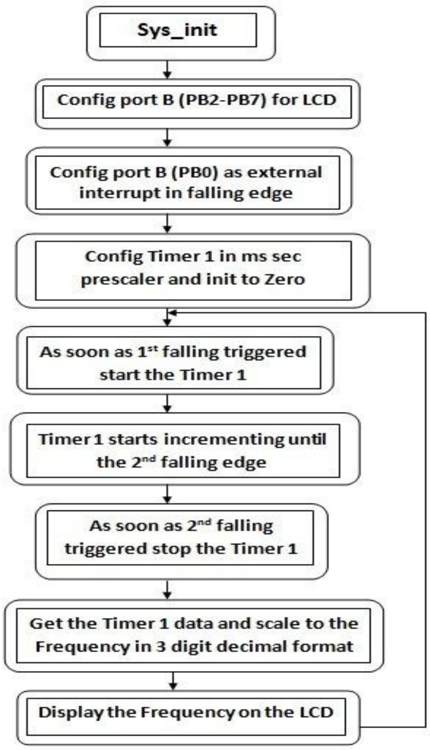


Fig. 3: Data Flow Diagram

Now, a Hex to Dec. converter block is used to convert the hexadecimal value into decimal value to display the data on 16X2 LCD as well as to send the PC Universal Synchronous Asynchronous Receiver Transmitter (USART) for future analysis.

4. Results

The pulse sent during the two falling edge is generated by a 10 MHz crystal controlled oscillator. So, the time interval between the same pulses is considered to be sufficiently accurate and hence, it does not require the comparison with other instruments of higher accuracy. The data sample shown below is acquired and displayed on the VDU of personal computer through serial port. The sample is taken in every 2 second interval.

Table.1: Data Sample acquired and displayed on PC

Sampling Time	Frequency
2Sec	50.096 Hz
2Sec	50.098 Hz
2Sec	50.106 Hz
2Sec	50.102 Hz
2Sec	50.102 Hz
2Sec	50.106 Hz
2Sec	50.100 Hz
2Sec	50.100 Hz
2Sec	50.108 Hz
2Sec	50.104 Hz
2Sec	50.106 Hz
2Sec	50.111 Hz
2Sec	50.110 Hz
2Sec	50.113 Hz
2Sec	50.116 Hz
2Sec	50.115 Hz
2Sec	50.113 Hz
2Sec	50.126 Hz
2Sec	50.127 Hz

Table2: Sample of Frequency at 07:00 am

TIME=> 7:00 AM	
Sampling Time	Frequency
2Sec	50.102 Hz
2Sec	50.103 Hz
2Sec	50.102 Hz
2Sec	50.096 Hz
2Sec	50.095 Hz
2Sec	50.099 Hz
2Sec	50.095 Hz
2Sec	50.095 Hz
2Sec	50.094 Hz

2Sec	50.091 Hz

Table 3: Sample of Frequency at 01:00pm

TIME=> 1:00 PM	
Sampling Time	Frequency
2Sec	49.751 Hz
2Sec	49.761 Hz
2Sec	49.842 Hz
2Sec	49.816 Hz
2Sec	49.951 Hz
2Sec	49.834 Hz
2Sec	49.743 Hz
2Sec	49.765 Hz
2Sec	49.797 Hz
2Sec	49.765 Hz

Table 4: Sample of Frequency at 07:00pm

TIME=> 7:00 PM	
Sampling Time	Frequency
2Sec	50.131 Hz
2Sec	50.135 Hz
2Sec	50.131 Hz
2Sec	50.135 Hz
2Sec	50.142 Hz
2Sec	50.141 Hz
2Sec	50.139 Hz
2Sec	50.144 Hz
2Sec	50.145 Hz
2Sec	50.146 Hz

Table 5: Sample of Frequency at 01:00am

TIME=> 1:00 AM	
Sampling Time	Frequency
2Sec	50.330 Hz
2Sec	50.319 Hz
2Sec	50.303 Hz
2Sec	50.293 Hz
2Sec	50.279 Hz
2Sec	50.290 Hz
2Sec	50.301 Hz
2Sec	50.293 Hz
2Sec	50.370 Hz
2Sec	50.380 Hz

5. Conclusion

The developed microcontroller system has been implemented on a printed circuit board with a microcontroller, LCD display system and some other interfacing components. Its cost is about Rs.1000.00 only, which shows very cost effective and efficient displaying system. This system will be very useful in power system when the frequency needs to be monitored.

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References

[1] V. Hamilakis, and N.C. Voulgaris, ," An accurate method for the measurement of line frequency and its deviation using a microprocessor",

[2] O. P. Mallik, G. S. Hope, G. C. Hancock, Li Zhaohui, Ye Luqing, and Wei Shouping,"Frequency Measurement For Use With A Microprocessor-Based Water Turbine Governor", IEEE Transaction on Energy Conversion, Vol 6, No.3, Page(s): 361 – 366, September 1991.

[3]P. J. Moore, R. D. Carranza, and A. T. Johns, "A New numeric technique for high-speed evaluation of power frequency", IEE Proceedings-Generation, Transmission and Distribution, Volume: 141, Issue: 5, Page(s): 529 – 536, Sep 1994.

[4] L. Tafoya and N. Salazar, "Microprocessor-Based Frequency Measurement", Automation Congress, 2002 Proceedings of the 5th Biannual World, Volume: 14, Page(s): 249 – 254, 2002.

[5] A. A. Girgis, "An accurate microprocessor-based technique for measuring frequency fluctuations in power systems", in Proc. 14th Ann. Pittsburgh Conf "Modelling and Simulation" (Pittsburgh, PA), vol. 14, Page(s): 65-69, Apr. 22, 1983.

[6] C. T. Nguyen and K. Srinivasan, "A new technique for rapid tracking of frequency deviations based on level crossings ", IEEE Trans. Power Appl. Syst., vol. PAS-I03, Page(s): 2230-2236, Aug. 1984.

[7] T. Kasparis, N. C. Voulgaris, and C. C. Halkias, "A method for the precise measurement of the difference between two low frequencies", IEEE Trans. Instrum. Meas., vol. IM-34, Page(s): 95-96, Mar. 1985.

[8] P.N.Neild "Method of Measuring Power System Frequencies", Proc. IEE, Vol. 117, Page(s): 157-160, Jan. 1970.

[9] M.S.Sachdev and M.M.GIRAY "A Least Squares Technique for Determining Power System Frequency", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-104, Page(s): 437-443, Feb. 1985.

[10] M. Mañana, J. A. Rodríguez, F. J. Sánchez, A. Ortiz, L. I. Eguíluz "Frequency measurement under non-sinusoidal conditions", www.icrepq.com/PONENCIAS/4.295.MANANA.pdf

[11] Loredana Cristaldi, Alessandro Ferrero and Simona Salicone "A Distributed System for Electric Power Quality Measurement", Instrumentation and Measurement Technology Conference, 2001. IMTC 2001. Proceedings of the 18th IEEE, Volume: 3, Page(s): 2130 – 2135, 2001.

[12] S. RUSTEMLI and M. ATES "Measurement and Simulation of Power Factor using PIC16F877", PRZEGLĄD ELEKTROTECHNICZNY (Electrical Review), ISSN 0033-2097, R. 88 NR 6/2012, pe.org.pl/articles/2012/6/68.pdf

[13] Dogan Ibrahim "Accurate Measurement of the Mains Electricity Frequency", ELECO 2011 7th International Conference on Electrical and Electronics Engineering, 1-4 December, Bursa, TURKEY. www.emo.org.tr/ekler/909fcedd9fd41ab_ek.pdf.

[14] A. Lueangvilai, C. Robertson, and C. J. Martinez, "A Dynamic Frequency Controlling Technique for Power Management in Existing Commercial Microcontrollers", Journal of Computing Science and Engineering, Vol. 6, No. 2, Page(s): 79-88, June 2012.